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ENZYMATIC CONTENT OF FEEDER ROOTS OF NURSERY STOCK

AS INDICATOR OF THEIR MYCORRHIZAL INFESTATION¹

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During the period between late July and the middle of September of 1978, the author performed determinations of the catalytic potential of feeder roots of nursery seedlings not exceeding 2 mm in diameter. The analyses included planting stock from 5 Wisconsin, 1 Michigan, and 1 Minnesota forest nurseries. As was disclosed by previous studies (Iyer *et al.*, 1978; Wilde *et al.*, 1978), the catalytic potential expresses the enzymatic content of roots and, in turn, the relative abundance of ectocellular mycorrhizae, alias mycorrhizal short roots. Table 1 outlines the relationship in question.

Analyzed stock	Catalytic potential mm Hg/g
2-year-old red pine, total roots	27.7 ± 2.4
Roots without mycorrhizal rootlets	12.0 ± 1.5
Mycorrhizal rootlets, less than 2 mm in diameter	48.2 ± 2.1
Nonmycorrhizal rootlets, less than 2 mm in diameter	16.2 ± 1.4
2-year-old white pine, total roots	32.3 ± 2.6
Roots without mycorrhizal rootlets	11.9 ± 1.9
Mycorrhizal rootlets, less than 2 mm in diameter	55.0 ± 2.7
Nonmycorrhizal rootlets, less than 2 mm in diameter	14.1 ± 2.2
3-year-old white spruce, total roots	21.2 ± 2.7
Roots without mycorrhizal rootlets	10.9 ± 1.4
Mycorrhizal rootlets, less than 2 mm in diameter	27.3 ± 3.1
No nonmycorrhizal rootlets	
2 to 5-year-old red pine of natural reproduction, total roots	
lacking mycorrhizal rootlets	12.2 ± 2.4
Nonmycorrhizal rootlets, less than 2 mm in diameter	14.8 ± 2.0

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The procedure for the determination of catalytic potential of tree roots was previously described (Lit. cit., 1978). It is simple and rapid, but obtaining reliable results requires meticulously careful sampling of trees. The trees should be excavated by a sharp spade entering the soil in a vertical position and removing a block of approximately 10 by 10 inches surface area. Trees with partly cut off roots are excluded from the sample. All samples must be collected from sections exhibiting uniform nursery stock, preferably of full stocking, and from the very center of nursery beds. The abundance of mycorrhizal short roots varies greatly in border- and centrally-located trees in accordance with the amount of radiation received by their foliage (Fig. 1).

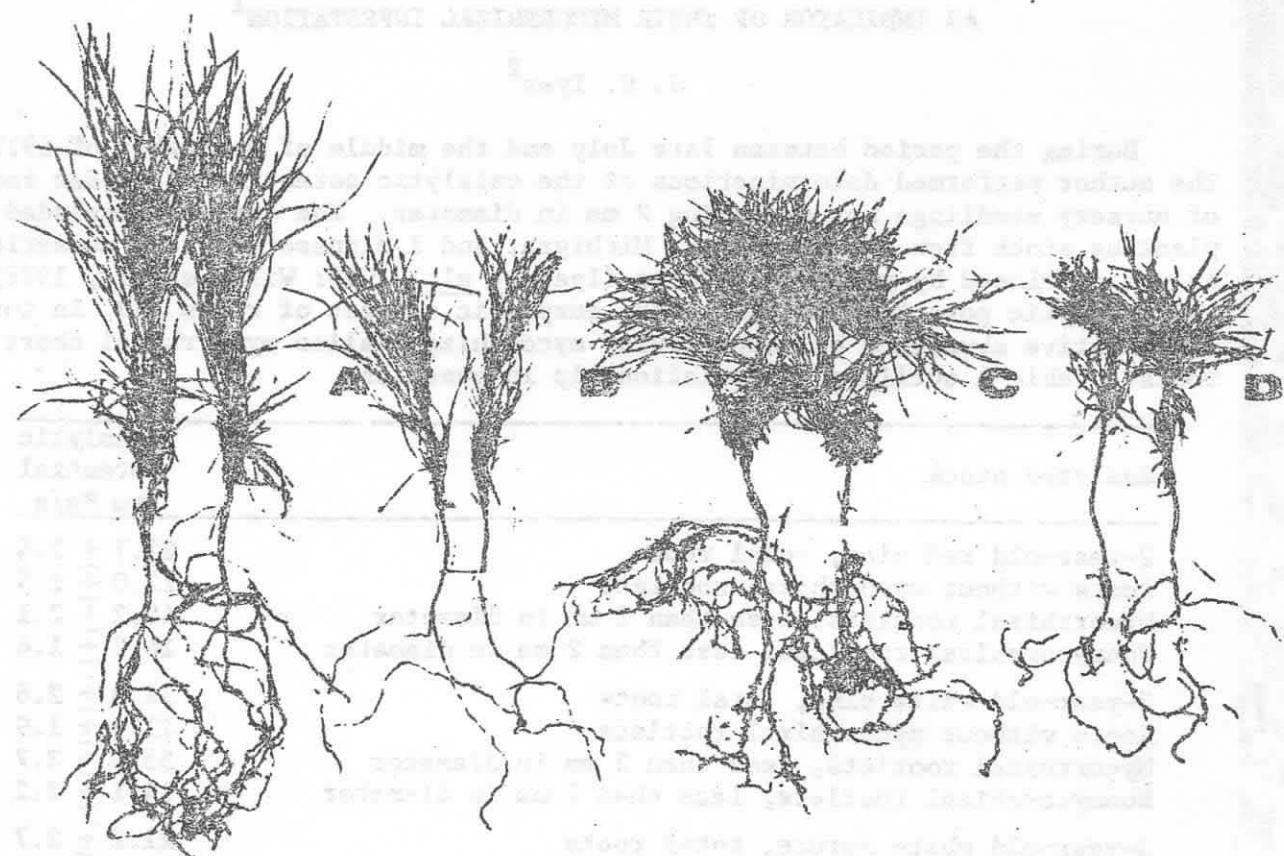


Fig. 1. Incidence of mycorrhizal short roots in 2-year-old red and white pine seedlings as influenced by the density of stock and exposure of the foliage to direct sunlight: A and C: red and white pine seedlings sampled from the border of nursery beds with catalytic potentials of 48 and 50 mm Hg/g, respectively; B and D: similar seedlings sampled from the center of the same beds with catalytic potential of 21 and 24 mm Hg/g, respectively (Wilson State Nursery of Wisconsin).

Results of Analyses

Aside from the density of nursery stock of different ages and subsequent exposure of the foliage to sunlight, the abundance of mycorrhizal short roots is influenced by several other conditions, such as the length of the growing season, properties of the soil, irrigation, and eradicator treatments. Detection of the effects of all these factors is outside the scope of this reconnaissance survey. The samples obtained from nearly every nursery exhibited low as well as high incidence of mycorrhizal short roots and provided no clue in regard to the levels of mycorrhizal infestation peculiar to individual nurseries.

All analyses reported in this note were performed on 2-g samples of air-dry rootlets not exceeding 2 mm in diameter, i.e., the rootlets bearing more than 90% of the short roots. Each sample was derived from at least 6 similar size trees. The analyses were performed using 15 ml of 6% hydrogen peroxide and 1 minute reaction time. As the difference between duplicate determinations very seldom exceeds 4 mm Hg, two analyses of roots of uniform nursery stock should provide reasonably reliable information. In this study, however, the averages were derived from at least 5 determinations permitting calculation of standard deviations. A comprehensive interpretation of the results requires consideration of all reported values, the average weight of total roots, the level of the catalytic potential, and its standard deviation.

Table 2. Incidence of mycorrhizal short roots in planting stock produced in Wisconsin state nurseries, determined on the basis of the enzymatic content of rootlets not exceeding 2 mm in diameter.

Nature of analyzed stock	Ave. weight of total root, g, and catalytic potential, mm Hg/g					
	Griffith		Hayward		Wilson	
Red pine, 1-0	0.3	39 ± 1.6	0.2	71 ± 2.7	0.3	58 ± 1.7
Red pine, 2-0	1.8	29 ± 1.2	1.9	49 ± 3.2	0.9	43 ± 2.1
Red pine, 3-0	2.9	20 ± 2.8	1.7	32 ± 3.3	2.4	30 ± 3.0
White pine, 2-0	1.5	38 ± 3.9	1.3	53 ± 1.1	1.1	32 ± 2.4
White pine, 3-0	2.8	19 ± 1.2	2.8	23 ± 2.1	1.6	21 ± 2.8
White spruce, 3-0	2.1	21 ± 2.0	2.1	29 ± 1.5	3.9	27 ± 3.1
White spruce, 2-2	4.1	12 ± 1.9				
White cedar, 3-0, with no short roots			1.9	19 ± 1.2		

Table 3. Incidence of mycorrhizal short roots in seedlings raised in U.S. Forest Service Hugo Sauer nursery of Wisconsin, J. W. Toumey nursery of Michigan, and Eveleth nursery of Minnesota, determined on the basis of the enzymatic content of rootlets not exceeding 2 mm in diameter.

Nature of analyzed stock	Ave. weight of total root, g, and catalytic potential, mm Hg/g			
	Hugo Sauer	J. W. Toumey	Eveleth	
Jack pine, 1-0			0.28	52 \pm 1.6
Jack pine, 2-0	4.40	42 \pm 2.2	0.81	55 \pm 3.2
Red pine, 1-0		0.36	54 \pm 3.7	
Red pine, 2-0		1.60	33 \pm 2.4	0.80
Red pine, 3-0		2.72	25 \pm 4.9	5.36
White spruce, 2-0		1.76	48 \pm 3.7	0.51
White spruce, 3-0		4.10	30 \pm 1.6	1.10

Table 4. Incidence of mycorrhizal short roots in seedlings raised in the Pine Lake nursery of Nekoosa Papers Co., determined on the basis of the enzymatic content of rootlets not exceeding 2 mm in diameter.

Nature of analyzed stock	Ave. weight of total root	Catalytic potential
	g	mm Hg/g
Red pine, 2-0	0.70	34 \pm 3.9
Red pine, 3-0	1.25	26 \pm 2.3

Fig. 2 illustrates root morphology of 2-year-old nursery red pine seedlings of a high and a low catalytic potential.

*Stock of low density.

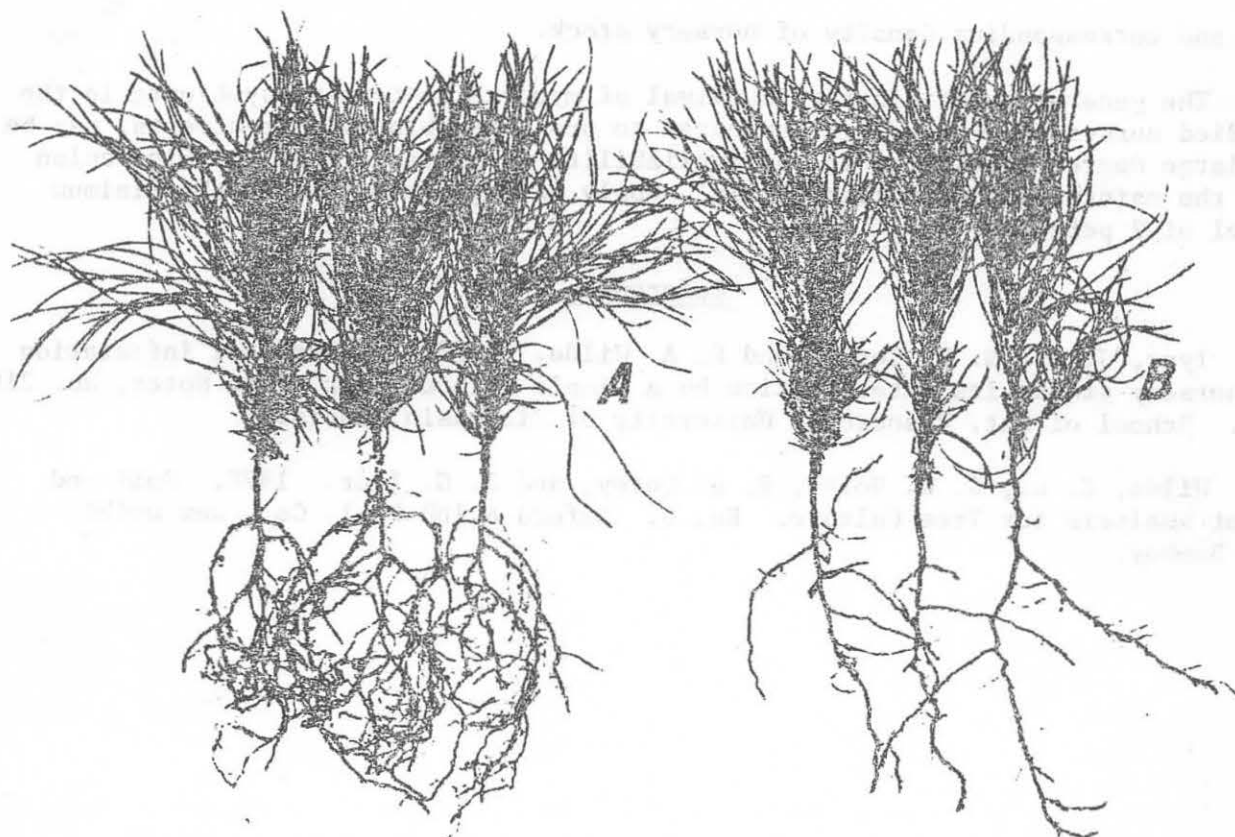


Fig. 2. Root morphology of 2-year-old red pine nursery seedlings with catalytic potential exceeding 45 mm Hg (A) and less than 30 mm Hg/g (B).

Conclusions

The results of this survey have provided additional information correcting the persistent omission in studies of ectocellular mycorrhizae, namely THE DECISIVE EFFECT OF RADIATION ON THE DEVELOPMENT OF MYCORRHIZAL SHORT ROOTS. According to our observations, the incidence of short roots in nursery stock is ~~inversely~~ related to the fraction of the foliage exposed to direct sunlight and, in fully-stocked nursery beds, to the age of trees. Considering the results obtained in this and previous studies, the relationship for nursery stock of jack, red and white pines and white spruce is expressed by the following averages: one-year-old seedlings - 55 ± 9.1 mm Hg/g; two-year-old seedlings - 42 ± 8.5 mm Hg/g; 3-year-old seedlings - 26 ± 7.2 mm Hg/g. These averages indicate a linear regression with a band of normality in the proximity of 8 mm Hg/g.

From a practical stand point, the obtained results strongly suggest that investigations aiming to disclose the effect of toxic eradicates or other adverse conditions on the development of mycorrhizae should first of all consider the

age and corresponding density of nursery stock.

The generally satisfactory survival of mycorrhiza-forming symbionts in the studied nurseries, which were subjected to prolonged biocidic treatments, may be in large degree attributed to the availability of suitable peat in this region and the maintenance of nursery soils' supply of organic matter at the minimum level of 2 percent.

References

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